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THE GERMINATION OF THE SEEDS OF CARAPA GUIANENSIS Aubl.

BY JOHN W. HARSHBERGER, PH.D.

The genus *Carapa* (nat. ord. *Meliaceæ*) comprises a number of tropical forest trees with pinnate leaves and flowers borne in few- or many-flowered axillary panicles. The following species of the genus are recognized by the Index Kewensis, viz.: *Carapa guianensis* Aubl. from Guiana and tropical Africa; *C. moluccensis* Lam. from the Malay archipelago; *C. nicaraguensis* C.D.C. from Central America; *C. procera* D.C. from Asia and tropical Africa; *C. surinamensis* Miq. from Guiana. *Carapa moluccensis* is a mangrove, and Karsten has removed this species from the genus *Carapa*, placing it under the generic name *Xylocarpus*.

The fruits of the plants of the genus *Carapa* are spherical or ovoid capsules, thick, woody, mostly warted, opening by septifragal dehiscence into five valves. The seeds are large, thick, angular, with woody brown seed-coats (Pl. VIII, figs. 1, 2, 3, 6). The food substance in the form of endosperm is wanting, and the cotyledons are thick and conferruminate (fig. 8*a*). The only illustrations of the fruits and seeds of this genus, as far as the writer has been able to ascertain, are those published by Engler and Prantl,[1] where the flowers, ovary and fruit of *Carapa procera* D.C. are shown, but not in germination. Lubbock and Karsten have studied the germination of the seeds of several related genera of the same order, *Meliaceæ*, and the substance of their studies is here briefly given by way of summing up our knowledge concerning the sprouting of the seeds of the plants of this family. Lubbock[2] describes and figures the germination and seedlings of *Melia azedarach* L. and *Walsura piscidia* Roxb. In the pride of China (*Melia azederach* L.) the cotyledons are linear-oblong, obtuse, narrowed to a short petiole. The first leaves are opposite, tripartite; the succeeding leaves are compound pinnate. The cotyledons leave the seed and become aerial. The cotyledons of *Walsura piscidia* Roxb. are fleshy, remaining in the seed. The first pair of opposite leaves are reduced to small brown scales, the third to the sixth are small, oval, emarginate and entire. The seventh to the ninth are much larger, oval, emarginate and entire. Engler and Prantl[3] illustrate the germination of the seeds of a species of *Xylocarpus* (*Carapa moluccensis*), the illustration being copied from a paper by Karsten.[4] From the figure (*H*), it would appear that the cotyledons remain enclosed in the seed, the hypocotyl being thick and fleshy. The radicular part, from which the secondary roots arise, is swollen and bulb-like. The first twelve pairs of leaves are opposite and scale-like. The stem arises from the point where the hypocotyl emerges from the seed. The following description of the germination of the seeds of *Carapa guianensis* Aubl. from material obtained in July, 1901, at Castleton, Jamaica, and preserved in two per cent. formalin, is, therefore, given as in part a contribution to the biology of the order *Meliaceæ.*

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[1] *Die natürlichen Pflanzenfamilien*, III, 4, s. 277.

[2] LUBBOCK, *Contributions to our Knowledge of Seedlings*, I, 335.

The capsule of this plant is large, about the size and shape of a cocoanut. It is ridged with four prominent warty-looking ridges which come together in a heavy apical protuberance.

There are four valves, thick ($\frac{1}{6}$ inch) and woody, separating from each other from the base upward to the apex. The capsule is filled with angular seeds (figs. 1, 2, 3, 4, 6), with a smooth or slightly wrinkled, brown outer seed-coat. Ten or a dozen of these large seeds are snugly packed away inside the woody fruit walls. Germination begins after the capsule has dehisced and while the fruit still lies upon the surface of the ground beneath the parent tree. The seeds start to germinate (fig. 6) before they fall out of the capsule, and later they are held in place by the intricately woven mass of secondary roots which grow in all directions between the closely wedged seeds. The stem elongates some four to six inches and emerges from the interior of the partially opened seed vessel between the slightly sprung edges of the valves (figs. 4, 5). All of the seeds of a single capsule may germinate *in situ,* and the complex of roots makes it a rather difficult matter to separate the seeds from each other after germination has once begun. It would seem that the seeds lose their vitality more or less quickly if allowed to remain for some time in a dry place. Some seeds that were left in a cool but dry room began to lose water and to decrease in weight, so that it seems that immediate germination is a means of insuring the perpetuation of the species.

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[3] ENGLER AND PRANTL, *Die natürlichen Pflanzenfam.*, III, 4, 279.
[4] KARSTEN, *Bibliotheca Botanica,* XXII, 21, Pls. 7 and 8.

The period of germination is gone through quite rapidly. The seeds sprout quickly and in about a month's time the plants are a foot high with several well-developed pinnate leaves of a rich, glossy green color (fig. 9). The seeds are about an inch to an inch and a half in diameter with sharp angular edges (figs. 1, 3). They are tetrahedra, with one of their faces, that applied to the rounded interior of the capsule, with a spherical curvature (fig. 3). The seed-coats are woody and about $\frac{1}{8}$ inch thick. The interior of the seed is filled up with the fleshy conferruminate cotyledons, which are of a yellowish-white color in section (fig. 8*a*). The parenchymatous cells of the cotyledonary masses are large, with comparatively thin cell walls. Sections of the cotyledonary tissue treated with glycerine clears the material and lozenge-shaped crystalloids are seen imbedded in the protoplasm of the cells (fig. 8*b*). Other sections treated with chloroform and then with iodine show these crystalloids quite clearly by the brownish-yellow hue that they take, the protoplasm staining a bright yellow color. At first it was thought that globoids were present because of the aggregated rounded masses found in the cells that were treated with alcohol. The application of chloroform and ether showed these masses to be oily in character. The oil dissolves readily in the chloroform, but tardily in the ether. In some old seeds, here and there, parenchyma cells were found to be filled with a yellowish resin-like substance, but more careful investigation failed to demonstrate the resinous nature of this substance. Starch is absent as a reserve material from these seeds. The materials, therefore, stored in the cotyledon consist of oil, proteid bodies (crystalloids) and protoplasm. This determination is substantiated by the fact that from the seeds of *Carapa procera, C. guianensis,* a commercial oil is obtained, having a slightly unpleasant smell and a bitter taste. This oil is known variously as Carapa oil, Talliconah oil, Crap oil, Carap oil, Andiroba oil, Touloucouna oil, or Coondi oil. The natives of Guiana rub their bodies with it as a protection against mosquitoes.

Germination begins by the cracking of the testa, or outer seed-coat, with the lifting off of flaky pieces (figs. 4 and 5). The tegmen is also broken through by the knob-like protruding portion of the embryo (figs. 4, 5). The radicle first protrudes as a roughened thick tubercular mass about one-fourth of an inch long, and from this arise six to ten secondary roots (fig. 4). The plumule, which points away from the tip of the radicle, lies in a cup-shaped depression formed by the swollen petiole-like bases of the conferruminate cotyledons (figs. 7, 8*a*). It is about two-fifths of an inch long. The base of it appears as a small knob through the slit left between the bases of the cotyledons. The hypocotyl is about one-fourth of an inch long. As the radicle grows out and down, the plumule straightens out by first assuming a U-shaped form (figs. 8, 8*a*). Later it becomes straight and grows upright. The radicle of *Carapa guianensis* does not assume the rounded, tuber-like form of that of the mangrove plant (*Xylocarpus granatum* Koen., *Carapa moluccensis* Lam.), figured and described by Karsten, nor does it show the horizontal aerating roots which develop vertically horn-like upgrowths with numerous lenticels for breathing purposes. The germination of the seeds of these two species is somewhat similar. The greatest difference lies in the formation of tuber-like radicle and the pneumatodes in *Carapa moluccensis*, the latter being developed as an adaptation to the conditions of a littoral life and growth in the water. *Carapa guianensis*, a land plant, in not possessing these structures during germination, shows that it is more primitive than the tree of mangrove habit which lives with its roots submerged.

The stem of the seedling rapidly elongates, bearing at first closely appressed scale leaves (fig. 10). After a time, there arises a pair of opposite, abruptly pinnate, bijugate leaves; the stem becoming woody at the base. Then succeed a pair of sub-opposite leaves which are large and monojugate. Each leaflet has a swollen pulvinus-like base. The succeeding leaves are bijugate; each leaflet has a pulvinus and thick dark-green blade about three inches wide and five inches long.

EXPLANATION OF PLATE VIII.

Fig. 1.—Side view of seed of *Carapa guianensis* Aubl.

Fig. 2.—*Idem,* end view of seed.

Fig. 3.—Seed of tetrahedral form from centre of the capsule.

Fig. 4.—Seed with cracked seed-coats and protruding radicle.

Fig. 5.—Seed showing roots, radicle, hypocotyl and stem papilla (*p*).

Fig. 5*a*.—Longitudinal section of the lower part of the embryo.

Fig. 6.—Seed which has just started to germinate.

Fig. 7.—Seed that has germinated (partially diagrammatic), showing the lower bent ends of the two conferruminate cotyledons.

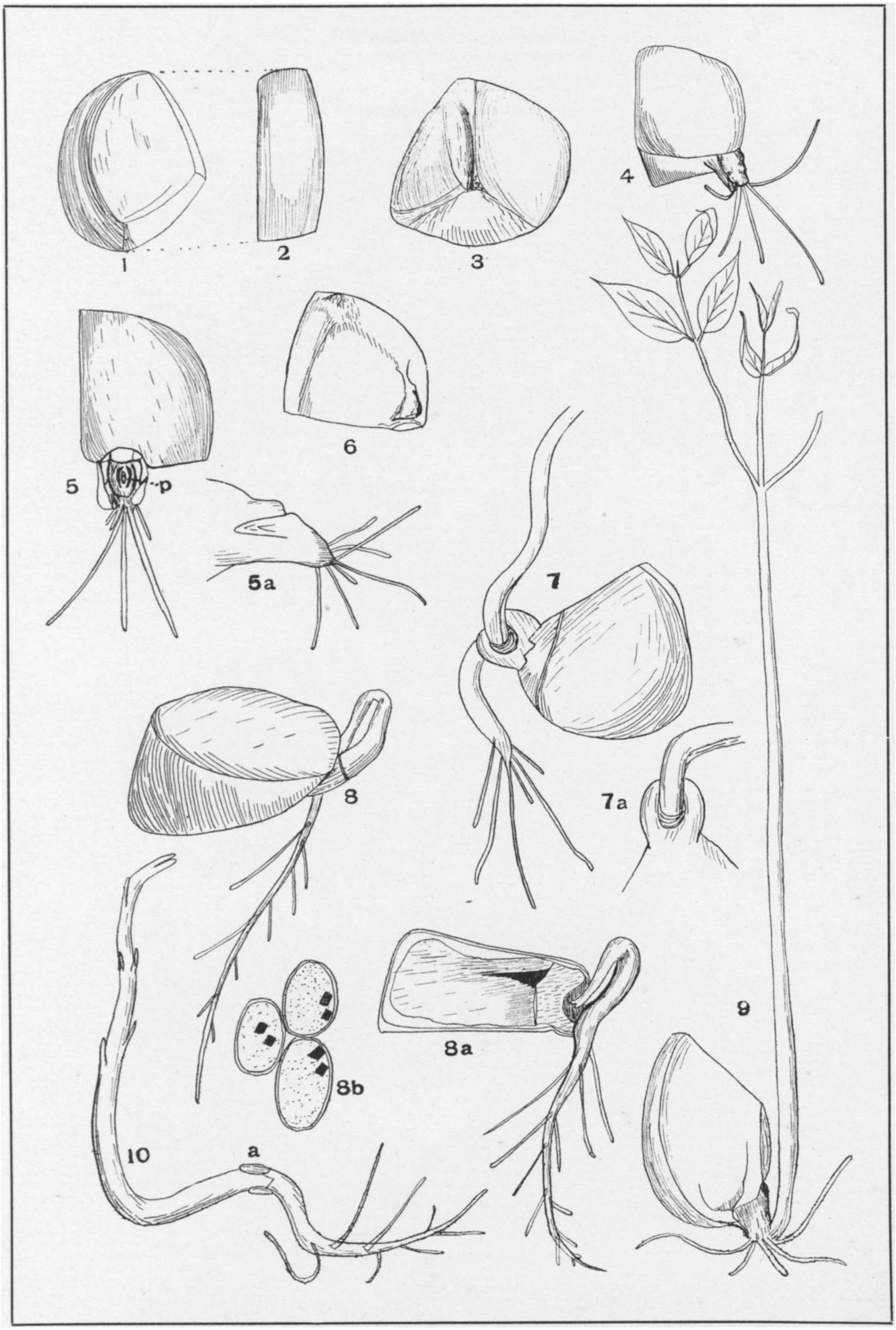
Fig. 8.—Seed in natural view, showing stem bent in U-shaped manner and the radicle.

Fig. 8*a*.—Longitudinal section of seed and embryo, showing solution of the reserve food.

Fig. 8*b*.—Several parenchyma cells from ungerminated seed, showing protoplasm and crystalloids.

Fig. 9.—Plantlet somewhat advanced.

Fig. 10.—Plant independent of reserve food; cotyledonary scars shown at (*a*).



HARSHBERGER. GERMINATION OF CARAPA.